**Gygis alba.
Lestris, sp. inc.
Puffinus, sp. inc.
——, sp. inc.
——, sp. inc.
Phaeton æthereus.
—— flavirostris.
Dysporus cyanops.
*—— sula.

The four species marked with an asterisk were observed by Mr. T. Peale on the Gilberts during Wilkes's U.S. Exploring Expedition, and the two marked with two asterisks are mentioned by G. R. Gray as occurring there.

Although my ornithological efforts look rather poor, I am otherwise very well satisfied with my investigations and collections. I have sent home thirty-two large cases of specimens, and among them a fine ornithological series. As I hope soon to visit the Carolines, I expect to be able to do more in my beloved branch of science, and to give greater satisfaction to my ornithological brethren.

XLIII.—Archæopteryx macrura, *an Intermediate Form between Birds and Reptiles.* By Carl Vogt, Professor in the University of Geneva[†].

(Plate XIII.)

In 1861 Hermann von Meyer, the distinguished palæontologist, described, in Bronn and Leonhard's 'Jahrbuch,' a Bird's feather found in the lithographic slate of Solenhofen, in Bavaria, belonging to the Upper Jurassic deposits. To the Bird revealed by this feather he gave the name of *Archæopteryx lithographica.*

Many of the learned believed it to be a skilful falsification. At that time the existence of Birds in the Jurassic epoch seemed as unlikely as that of Mammals in the Triassic.

Doubts were soon dispelled by Prof. Owen's memoir, published in the 'Philosophical Transactions' for 1863. Herein he described, as he alone knows how to do, a slab found by Dr. Häberlein, a physician at Pappenheim, which showed with remarkable clearness the hind-quarters of the Bird whence, doubtless, came the feather described by Herr von Meyer. The pelvis, the legs, the long tail furnished with feathers were grandly preserved; but, except the wing-feathers, which were disordered, and some loose and dislocated bones belonging to the anterior extremities, all the rest of the skeleton was wanting. Prof. Owen himself compared the remains preserved in the slab to those of a sea-bird cast upon the shore, after all the fleshy parts had been eaten by carnivorous animals.

[†] Read at the Saint-Gall Meeting of the Congress of Swiss Naturalists, and translated from the 'Revue Scientifique,' sér. 2, ix. p. 241 (13th Sept. 1879).

In spite of these defects, the slab was bought for a very considerable sum by the British Museum, Mr. Waterhouse having been sent to Pappenheim for that purpose. Prof. Owen, I hardly know why, changed the specific name from *lithographica*, given by Herr von Meyer, to *macrura*, struck, as he was, by the considerable length of the tail.

Three or four years ago the son of the late Dr. Häberlein found a slab which he suspected, from seeing one of the leg-bones, to contain a second example of *Archæopteryx*. He succeeded in splitting the slab so as to have on one of its halves the whole animal, and on the other its impression. Very skilful in such work, he succeeded in disengaging almost the whole skeleton from its bed, and offered it for sale, together with a very remarkable collection of Solenhofen fossils, containing twenty-six drawers of beautiful specimens (Algæ, Insects, Crustaceans, Cephalopods, Fishes, and Reptiles), to the number of at least three hundred.

The collection, of which the *Archæopteryx* was the principal ornament, was sold for 36,000 marks to Herr Volger, Director of the Freie Deutsche Hochstift at Frankfort-on-the-Main. The contract expressly stipulated that no reproduction by modelling, photography, drawing, or any other process should be permitted before payment had been made in full. Seals having been placed on the collection, Herr Volger carried off the principal slab to Frankfort.

Herr Volger nursed the hope that the Emperor William would buy the specimen to preserve it to Germany. His Majesty did not enter into these views. Ah! if, instead of a bird, a petrified cannon or gun had been concerned!

After having resumed possession of his treasure, Herr Häberlein addressed himself to me, in the hope that the Museum of Geneva would be able to acquire the collection at the much reduced price of 26,000 marks. This sum, otherwise suitable, much exceeding the resources of the Museum, it was necessary to let it go.

However, about the end of March last, I went to Pappenheim to see the collection. Having only one morning at my disposal, I was unable to make a thorough investigation, though what I saw filled me with enthusiasm. I promised Herr Häberlein to do all I could to obtain the price asked, and to help the sale, so that the specimen could be studied by everybody. Herr Häberlein has entrusted me with a photograph of the natural size, with the condition that I should not permit any reproduction whatever of it *.

The animal preserved in the slab is of the size of a Ring-Dove. The remains described by Prof. Owen belong to the same species, but to an example greater by a fifth.

The new specimen is entire. The head, neck, trunk, and hind-quarters are placed in profile, the head bent backwards, so that its top nearly touches the back. The wings, united at the shoulder-girdle, are spread as if for flight. The anterior extremity of the head and the pelvis are still embedded. The left leg is only disengaged so as to show half of its length, the femur and the upper half of the tibia being covered by the feathered thigh of the right leg.

The head is small, pyramidal, the top nearly flat, the occiput obliquely truncated. It is much compressed, and the anterior extremity not wholly disengaged. The orbit is large, with the nostril in front of it. By means of a lens two little conical and sharp teeth are perceived at the end, planted in the upper jaw. On the lower surface a forked bone is seen behind. I dare not say whether this is the lower jaw, which in that case would be very slender and weak, or whether it is the tongue-bone, developed as in the Woodpeckers. An elaborate study, and one requiring much time and care, would be needed to

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* [The photograph (Pl. XIII.) accompanying this paper was taken after the specimen had passed out of Herr Häberlein's hands.—Ed.]

describe the bones of the head, but what one sees shows clearly that it is a true Reptile's head.

Behind the occiput, on the first cervical vertebra, a long spinal apophysis, directed backwards, seems to be visible. It perhaps bore a crest, like that of the Iguanas, traces of which, one thinks, may be perceived.

I count, in an uncertain way, it is true, eight cylindrical cervical vertebræ. They are furnished with ribs, very fine, but easily recognizable, and directed backwards.

The neck, as a whole, must have been very movable. In this example it is bent in the form of a horse-shoe, the convexity formed by the ventral surface. Its length equals that of a Pigeon of the same size.

The dorsal vertebræ appear to be ten in number. They are thick, short, as broad as high, and have no spinal apophyses. The ribs which are attached to them are very fine, thin, curved and pointed at the end, like surgeons' needles, and show no flattening nor trace of uncinate processes, as in Birds. There are some very fine sternal ribs, which seem fixed to an abdominal linear sternum.

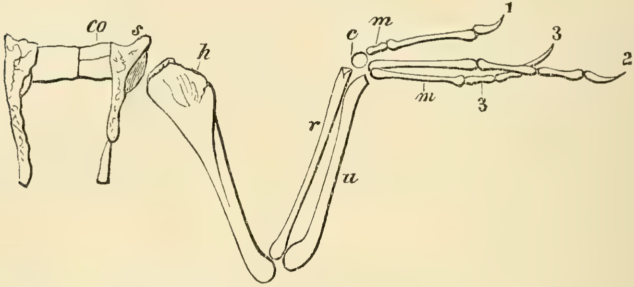
The pelvis, most part of which is preserved in the London specimen, is in this still embedded.

The tail is very long, and its whole length preserved. However, it only shows the vertebræ of its anterior half completely preserved. A fracture of the slab crosses the terminal feathers of the tail at the third of their length.

Prof. Owen has very well proved that the pelvis, as well as the hind-limb, entirely bear the stamp of the structure of a Bird by the reduction of the fibula, by the fusion of the tarsals and metatarsals into a single bone, and by the feet possessing four toes, of which one is placed behind. These parts are much better preserved in the London slab than in the present, in which some of the toes are wholly hidden. It would therefore add nothing to our knowledge of these parts, if it did not make quite certain that the fibula is wholly united to the tibia, and is only rendered perceptible by a slight longitudinal furrow. This structure can be affirmed, the right tibia showing it by its outer, and the left by its inner surface.

The fore limb (fig. 1), bearing the wing-feathers, is undoubtedly the most interesting. The two wings are flatly extended in the position of flight, the joints twisted so that the ulnar side, to which the remiges are attached, is turned backward. The two limbs composing the shoulder-girdle present their dorsal aspect; the body has come away from the girdle and is turned backward with the head and neck. Thus the hollow inner surface of the shoulder-girdle, that which is presented to the intestines, is seen.

Fig. 1.



Fore-limb of *Archæopteryx*, from above. Half the natural size.

I admit that I have had much trouble in clearing up the structure of the shoulder-girdle, and I am not sure that I have guessed right.

In our example there is seen only a median plate, slightly concave, 7 mm. long and 12 mm. wide, which looks a little like the throat-piece that soldiers formerly wore. This plate is split exactly in the middle, and I believe that this fissure is a symphysis; but I am not sure, for a similar split, evidently the result of a fracture, is observable in the right half of the bone.

Two long bones, a little twisted, and projecting very much, directed backwards and upwards, are attached laterally to the sides of this median plate. They have been somewhat injured by the splitting of the slab; but if they were brought into their normal position opposite the trunk they would lie longitudinally above the ribs, parallel to the vertebral column.

The somewhat flattened glenoidal head of the humerus articulates at the point where these bones meet the median plate.

These two bones may thus be taken for scapulæ (fig. 1, *s*), formed nearly as in Pterodactyls and Birds.

If this determination be right, one has to ask what is become of the other bones of the shoulder-girdle—the coracoids, the clavicles, and the sternum.

The London slab shows the two scapulæ wholly detached. Prof. Owen has described besides an injured bone, having the form of a hook, which in that slab is entirely isolated, calling it the furcula. In our specimen we see no trace of this furcula, so characteristic of Birds. It is possible that this bone may remain in the counter-slab, or that it may be lost; but either supposition seems to me hardly probable. I incline rather to think that the bone Prof. Owen calls the furcula is rather the pubis, which, in our specimen, is still hidden in the matrix. Here are the facts on which I rely:—

The pelvis described by Prof. Owen is only rudimentary, and consists, according to him, of parts of the iliac and ischiatic bones united around the acetabulum. The pubis is wanting. Whether, he says, "it has retained its individuality in *Archeopteryx**, or has been broken away from the part of the ilium indicative of the place of its original attachment and relations to the acetabulum, I cannot determine. So far as the appearance of the pelvis can be discerned and, by me, interpreted, they give no evidence of a reptilian structure." I believe that Prof. Owen would not now formulate an opinion so positive, when we know better the pelvis of the Dinosaurs, so like that of Birds.

By examining the pelvis of the Pterodactyls, and especially of the *Rhamphorhynchi*, I am come to the conviction that the bone described by Prof. Owen as the furcula ought to be the pubis. Andreas Wagner described and figured the pubis of the *Rhamphorhynchi* in the Memoirs of the Academy of Munich (viii. 1862, pls. 6, 17). He says, "The two pubic bones are united into a single bone, long, curved, and twice bent angularly." One would take these bones for a furcula if one had not seen them in position, and if one did not know positively that the Pterosaurs had no furcula.

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* [It is to be noted that throughout his memoir Prof. Owen preserves this erroneous spelling of the word *Archæopteryx*.—TRANSL.]

The pubis being missing from the London slab, the furcula from ours, otherwise so perfect, and Prof. Owen's supposed furcula being wholly detached and broken, I accordingly believe (considering the remarkable agreement of the Pterosaurs) that it is the broken pubic bone which Prof. Owen described, that the *Archæopteryx* was, like the Pterodactyls, unprovided with clavicles, and that it had the pubis consolidated into a single bone. Further examination of our slab can alone decide this controversy.

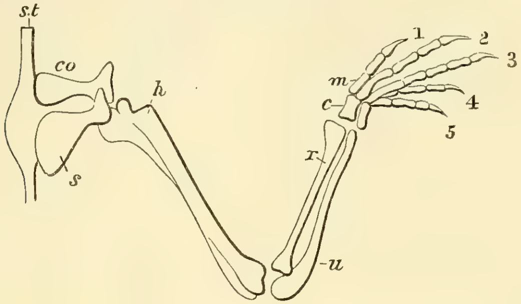
Dismissing the clavicles, the coracoids and sternum remain. One or the other must be wanting in *Archæopteryx*, for neither the London slab nor the new one allow of both these bones being found.

The first thought which offers itself is that the median plate, extending between the two scapulæ in our specimen, must be the sternum. In that case the coracoid would be wanting.

Now the coracoid (*co*) is never wanting in Reptiles and Birds. With the scapula, it is the most important, I would say the most normal, portion of the shoulder-girdle in all the Sauropsids that are furnished with fore-limbs. While the clavicles (*f*) and the sternum (*st*) may become rudimentary, or even fail completely, the coracoid always unites with the scapula in forming the humeral joint.

The shoulder-girdle of the Crocodiles and the Pterosaurs partly corresponds with the simple structure that we suppose *Archæopteryx* had. The shoulder-girdle of the Crocodiles, detached from the trunk and placed in the position of that of our *Archæopteryx*, shows (fig. 2) coracoids, long, flat, and widened above, turning back round the ventral face of the thorax, so as to be attached to both sides of a sternum elongated into a very fine point, and widening only behind the meeting surfaces. The upper rounded side of the coracoid is united to the scapula by very tight ligaments, and in the posterior angle of their junction is hollowed the articular cavity of the humerus, in which the scapula takes the greater share.

Fig. 2.



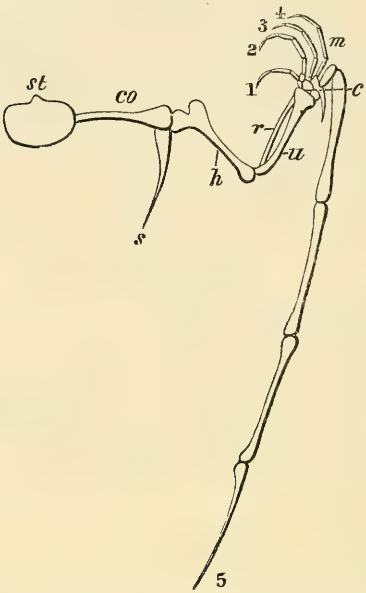
Fore-limb of Crocodile.

If we were to suppose the scapulæ straight and elongated, sabre-shaped instead of triangular, and the narrow part of the sternum reduced to nothing, so that the two coracoids could meet in the median line, we should have the shoulder-girdle of *Archæopteryx*.

Now the first of these conformations is realized in the Pterodactyls, where the scapulæ are like those of Birds, while the sternum is widened in the shape of a shield (fig. 3). On the other hand the reduction of the sternum is found in the Ichthyosaurs and the Plesiosaurs. The scapula of these animals is long and straight, but directed vertically from below upwards, while that of Birds, of Pterosaurs, and of *Archæopteryx* runs parallel to the vertebral column. On the other hand, in the Halosaurs the two coracoids meet by symphysis in the middle line; the sternum is wanting, but there is an episternum, which, in its turn, fails in *Archæopteryx*. The Ichthyosaur has clavicles, which are wanting in the Plesiosaurs.

I come, then, to the conclusion that the shoulder-girdle of *Archæopteryx* is that of a Reptile, that the furcula and the sternum, widened into a buckler and bearing a keel (so characteristic of all Birds except the Ratites), were completely wanting in it, and that the other bones, both in their combination and their form, offered characters which are found in the Halosaurs, the Pterosaurs, and the Crocodiles.

Fig. 3.



Fore-limb of *Rhamphorhynchus*. Natural size.

The humerus (*h*), the ulna (*u*), and the radius (*r*) have already been described with remarkable sagacity by Prof. Owen. The humerus, with its flattened articular head, offers some likeness to that of the Crocodiles. It bears no trace, any more than does the femur, of a pneumatic foramen, and nothing indicates the pneumaticity of the other bones, which is, however, established in the Pterosaurs. The bones of the fore-arm are separate throughout their whole length, and the ulna is stouter than the radius. Otherwise these bones offer no characteristic feature peculiar either to Reptiles or to Birds.

The manus presents some peculiarities which must necessarily have escaped Prof. Owen, in whose specimen there were only its scattered and imperfect remains.

The carpus (*c*), as Prof. Owen rightly says, shows only a single spherical bone. Birds and Crocodiles have two carpals, one on the side of the radius, the other on that of the ulna. Some of the Ratites with rudimentary wings, such as the Cassowary and Apteryx, have only a single carpal; and, as that character is combined with the rudimentary or nullified clavicles, we find in it some resemblance to *Archæopteryx*. I do not know whether the single carpal occurs in the Dinosaurs, for *Compsognathus*, the only one of them whose entire skeleton has been left to us, seems to have had the carpus in a cartilaginous state.

Prof. Owen assigns four digits to the manus. According to him, some scattered bones indicate that, besides those which bore the remiges, there were two slender digits, moderately long, and armed with curved, flattened, and sharp claws.

Relying on these facts (which are partly supposed, for he did not find the bones which bore the remiges), Prof. Owen discusses the difference between the manus of Birds, Pterosaurs, and the *Archæopteryx*; and, having proved that the latter had no extraordinarily elongated digit, as in the Pterodactyls, he continues:—"But besides the negative evidence, the positive proof of the ornithic proportions of the hand or pinion, of the existence of quill-feathers, and the manifest attachment of the principal ones, or 'primaries,' to the carpal and metacarpal parts of a short terminal segment of the limb, sufficiently evince the true class-affinity of the *Archeopteryx**."

Prof. Owen only knew, as we have just said, some scattered small bones of the manus. Prepossessed by the resemblances which connect the fossil with Birds, he readily supposed that the missing bones were constructed as in them. However, when our specimen shows all the bones of the fore limbs in their normal relative positions, equally to one another as to the feathers, we can affirm that the manus of *Archæopteryx* can neither be compared to that of a Bird nor of a Pterosaur, but only to that of a tridactyl Lizard.

In fact our specimen has on each manus three long slender digits, armed with claws, hooked and sharp-edged. The radial digit or pollex (1) is the shortest, the other two are nearly of equal length, but the second is longest. These two digits were evidently united by tendinous and close aponeuroses; for in each manus these digits are placed in the same way, the one overriding the other. The pollex is composed of a short metacarpal (*m*), a pretty long phalanx, and of a terminal claw-bearing phalanx; the other two digits have, besides the metacarpal, three normal phalanges.

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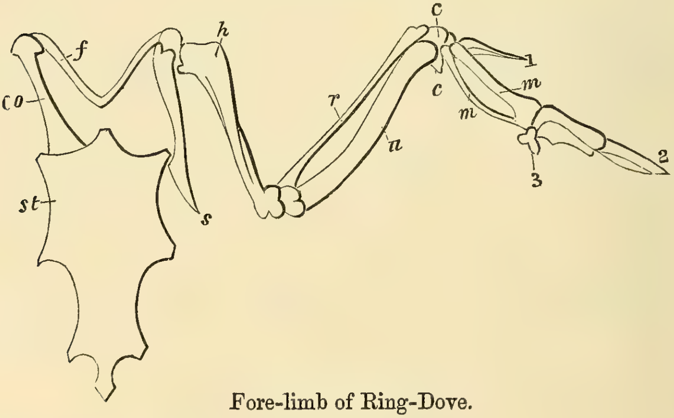
* [See former note.—Transl.]

The remiges were fixed to the ulnar side of the fore-arm and manus, though no special adaptation to this end can be observed in the skeleton. The pollex was free, like the other two digits, and bore no bastard-wing. If, in imagination, we could for a moment remove all the feathers, we should have before our eyes the tridactyl manus of a Reptile, such as *Compsognathus* and many other Dinosaurs seem to have had, to judge from their foot-prints. I assert that no naturalist, on being shown the skeleton of *Archæopteryx*, alone and without the feathers, could suspect that this animal had been in its lifetime furnished with wings.

The manus of *Archæopteryx* cannot be compared to that of a Bird. In the latter (fig. 4) the pollex (1)—sometimes wanting, as in *Eudyptes*—is placed at the base of the metacarpus and directly on the carpus; its single segment sometimes bears a spur or a nail; the metacarpus is formed of two

Fig. 4.



Fore-limb of Ring-Dove.

bones that coalesce at their extremities, but sometimes still separate, as in *Eudyptes*. This characteristic metacarpus bears two digits—one, the longest, with two phalanges; the other, often rudimentary, with one phalanx. Both these digits are flattened, unprovided with nails, and united together by ligaments, so as to be immovable. The manus of the Bird is adapted to bear the remiges, that of the *Archæopteryx* is not so in any way.

We can here sum up the facts as regards the skeleton. The head, the neck, the thorax with the ribs, the tail, the shoulder-girdle, and the whole fore-limb are plainly constructed as in Reptiles. The pelvis has probably more agreement with that of Reptiles than with that of Birds. The hind-foot is that of a Bird. Reptilian affinities therefore prevail, in the skeleton, over all others.

There remain the feathers. Here, no doubt, there are Bird's feathers, with a median shaft having barbs perfectly formed. The horny substance of the feathers has vanished, but the model in the fine paste of the lithographic stone is so perfect that the smallest details may be studied with the lens. The new slab shows all the feathers in their place.

The remiges of the wings are fixed to the ulnar edge of the arm and to the manus; they are covered for nearly half their length with a fine filiform down. None of them project beyond the others; the wing is rounded in its outline, like that of a Fowl.

It is possible that at the base of the neck there was a ruff, like that of the Condor. Some traces of it are perhaps visible.

The tibia was clothed with feathers for the whole of its length. The *Archæopteryx* thus wore breeches, as do our Falcons, to the legs of which its own leg bears, according to Prof. Owen, the most resemblance.

Each caudal vertebra bore a pair of lateral rectrices.

All the rest of the body, the head, neck, and trunk were evidently naked and unprovided with feathers. No traces of either down or feathers are there to be seen, though such would certainly have been found in a slab which has preserved the fine down in its smallest details. It thus follows that the restorations of the animal hitherto attempted are wholly erroneous.

After what we have just set forth, it would be quite superfluous to discuss the question whether *Archæopteryx* should be ranked among Reptiles or among Birds. It is neither one nor the other. It forms an intermediate type of the most marked kind, and confirms, in a brilliant way, the views of Prof. Huxley, who has united Birds and Reptiles, to form of them, under the name of Sauropsids, a single great section of Vertebrates. *Archæopteryx* is doubtless one of the most important guide-posts on the road followed by the Class of Birds in more and more differentiating itself from the Reptiles, whence it has drawn its origin. Bird in its integument and its feet, *Archæopteryx* is Reptile in all the rest of its organization, and its structure can only be understood by admitting the evolution of Birds by a progressive development from certain types of Reptiles. The Cretaceous Birds, so well described by Prof. Marsh, form a further guide-post upon this road, since they still keep their teeth, though nearly the whole of their organization has already conformed to the type of Birds.

But it concerns us to discuss a little more precisely the halting-places of this progressive evolution, and also to give some account of the way in which adaptation for flight has acted on different parts of the body.

Besides the power of flying, Birds are yet distinguished from most Reptiles, the Dinosaurs excepted, by their vertical position on their hind limbs alone.

In a paper published some time ago (Westermann's 'Illustrirte deutsche Monatshefte,' xlv.), I tried to prove that the adaptation of Vertebrates to flight is not necessarily combined with their adaption to an upright position, and also that the transformation of the hind-limbs, so far as to become the sole props of the body in walking, is wholly independent of the transformation of the fore-limbs to the end of becoming wings. The freeing of the fore-limbs from their function of props while at rest or in walking can, in fact, be attained in two ways, entirely opposite. In the one case they are shortened, so as to become useless or serviceable only as organs of prehension; in the other they are lengthened, so as to become organs of flight.

In Vertebrates we see the tendency to an upright position developed in Dinosaurs and Birds among the Sauropsids, and among Mammals in Kangaroos, Jerboas, and the Anthropomorphs, including Man. It is to be remarked that this tendency is, without doubt, very ancient: Dinosaurs appeared so early as the Triassic beds, and Kangaroos, since they are Marsupials, may make us believe that some of the Jurassic Marsupials—resembling the Kangaroo-rats (*Hypsiprymnus*) in their dentition—may have already shown the peculiar structure of animals that leap. Anyhow, the tendency is shown by the greater fixity and solidity of the pelvis, which is made up of a greater number of sacral vertebræ, by the increased length and thickness of the leg-bones, and lastly, except in the Anthropomorphs, by the progressive diminution in the number of the digits, which, on the other hand, become thicker and longer. The Anthropomorphs alone form an exception from this point of view; and the diminution in the number of digits being a general law for derivative types, we may say that they are, as regards these members, conservative beyond all others. As for the rest, this diminution, which carries with it that of the tarsal and metatarsal bones, is constantly shown.

The adaptation to flight is wholly independent of an upright position. The Pterosaurs and Bats, beyond question excellent fliers, prove this proposition in a decisive way. Both have the hind-feet very weak, short, furnished with slender digits, which are quite separate and armed with claws. We have only to observe the difficulty with which a Bat walks to convince ourselves directly that it could never hold itself upright on its hind-limbs; and comparing the skeleton of a Pterodactyl or of a *Rhamphorhynchus* with that of a Bat, we shall be directly persuaded that the Pterosaurs were well able to cling to any thing by their hind feet, but never to hold themselves upright. The structure of the hind-limbs, as seen in the Dinosaurs, in *Archæopteryx*, and in Birds, is therefore independent of the power of flight, and only relates to that of supporting the body on the hind-feet alone.

Now I believe I have shown in the above-mentioned article that all the characters whereon are based the consideration of Dinosaurs to be regarded as the ancestors of Birds are only related to the development of the power of keeping an upright position upon the hind-feet. Thanks especially to the labours of American naturalists, we now know that the feet of the Dinosaurs had but three digits, with the indication, sometimes, of a fourth; also that these animals walked upright, as shown by their numerous foot-prints, formerly attributed to Birds, and that their pelvis resembled that of Birds. On these principles they had then a resemblance to Birds and to the *Archæopteryx*; but the known skeleton of *Compsognathus* and other recognized facts show us that this development of the hind-feet was combined, as in the Mammals that leap, with a more or less considerable shortening of the fore-feet, which is in direct contradiction to the adaptation for flight, demanding, as that does, an elongation of the fore limb. Certain Dinosaurs, perhaps, perched like the *Archæopteryx* and Birds; but they were not more in the road to adaptation for flight than are the Tree-kangaroos of the New-Guinea forests (*Dendrolagus*), which also perch, in spite of their feet being adapted to leaping.

As to the adaptation for flight, we see it act in two directions, wholly distinct, according as the surface opposed to the air is formed by an extended membrane or by feathers. The manus of Pterosaurs and Bats obeys the mechanical conditions of the extended membrane, that of Birds is modified with a view to the remiges. These are, especially, the forms of manus which show the fundamental differences arising from different mechanical conditions

The shoulder-girdle in all flying animals exhibits a construction fit to ensure great fixity, united with considerable mobility, but limited as to the extent of movement. This fixity is due, in the first place, to the development of the coracoid, and, secondly, to that of the scapulæ and the clavicles. The sternum takes a notable part therein by developing considerable surfaces for the attachment of muscles. Sometimes it is a rounded buckler, as in *Rhamphorhynchus*, sometimes a keel, as in the Bats, or a combination of both, as in Birds, where the union of the three bones, coracoid, scapula, and furcula, forms an immovable pyramid, bearing the arm-joint on its summit. The humerus is a little elongated; but it becomes very thick and presents powerful muscular ridges. The fore-arm is still more elongated. If one of the two bones of the fore-arm becomes rudimentary, as in the Bats, the other gains in length and thickness. In general, the anterior extremity in all flying animals is elongated altogether, which is in direct opposition to its conformation in animals that leap, such as the Dinosaurs, where it is shortened. If Birds' wings seem to us short, it is because of their articulations bent in an extreme zigzag; and we may easily convince ourselves, either by measuring or extending them, that, when extended, the wings reach the ground in nearly all Birds, except the long-legged Waders, if the body be put in the position which it takes in a quadruped.

If all these conformations are common to all flying animals, differences begin to show themselves at the carpus. The animals that fly by means of an extended membrane preserve the primitive number of five digits, these digits being always elongated and slender; while in those that fly by means of feathers the number of digits is reduced by the union of some with others, either by symphysis or very strong ligaments—carpus and metacarpus following these modifications of the digits. Both these methods of adaptation, so different, and even so opposite, thus depend on the nature of the integuments with which the surface opposed to the air is furnished.

Let us first examine adaptation to flight by means of an extended membrane.

In the Flying-squirrels (*Pteromys*), the *Galeopithecus*, and in some Marsupials (*Petaurista*) we see all the digits free and armed with claws. The skin, covered with hair, and extending in folds between the fore- and hind-limbs, only serves as a parachute, and not as an active flying-membrane.

We now know, by the discovery at Solenhofen of some perfectly preserved wings of Pterosaurs, that their wing was formed by a stiff membranaceous border, finely folded and rather narrow, attached to the exceedingly elongated fifth digit, and extending to the anterior part of the body without reaching the hind-feet. I have before me a photograph, of the natural size, of the wing of *Rhamphorhynchus gemmingki*, which shows this structure most conclusively. After these discoveries, we may say that all the restorations of Pterosaurs found in books are wrong. The other digits, four in number, are slender, free, and armed with sharp-edged claws; while the fifth digit, so strong and so elongated, to which the membrane is attached, bears no nail at all.

In the Bats, four digits are fine, elongated, pointed at the end, and arranged like the ribs of an umbrella, while the fifth, the thumb, is free, short, and alone armed with a claw.

Step by step I have followed the development of the wing in the embryos of Bats. At first the manus of these animals is formed exactly like that of all other Mammals with five digits, and is so like the pes that it is difficult to distinguish the two limbs when they are separated from the body. The embryonic tissue wholly envelops the digits, which do not protrude from the circumference of the primitive disk. Later the various parts are differentiated; but while at the anterior extremity the membrane which unites the digits follows them as they by degrees are lengthened, behind it stops on the feet, where the digits become free by passing through it. The flying-membrane of Bats is thus no new structure, but only the primitive membrane uniting the digits developed equally with them.

We have, then, three stages of adaptation to flight by means of a membrane.

The first is represented in the volant Squirrels and Marsupials: the skin of the body is alone concerned, the skeleton taking no part in it: the organ of flight is still passive. As soon as it becomes active, osseous parts are needed as supports on the one hand, and on the other muscles to put the levers in motion. Furthermore, arrangements for extending or folding the flying-membrane are necessary. We thus see on the one hand a corresponding modification of the shoulder-girdle, which is the supporting point around which the muscles are disposed, and on the other hand a modification of the digits. In the Pterosaurs, which were, no doubt, weak fliers, there was only a single digit employed. In the Bats four digits are made use of, and only one, the thumb, keeps its original nature.

The series of halting-places in the progressive adaptation for flight by means of feathers is less complete.

Everybody knows the bony framework of the Bird's wing (fig. 4). The sternum is very large, and commonly furnished with a keel; the coracoid is very strong; the clavicles are united together to form the furcula; the humerus is often, and the fore-arm always, elongated; the carpus is formed by two insignificant bones only; the only two metacarpals are united together; and only one long stiff median digit is developed, while the two other digits are rudimentary or may even be wholly wanting. The elongation, with the view of gaining space for the insertion of feathers, the reduced number of digits, the greater fixity of the wing-joint, and the establishment of considerable surfaces for the insertion of muscles characterize this modification, which reaches its utmost in the Birds which are good fliers.

The halting-place of *Archæopteryx* may be in some measure compared with that of *Galeopithecus* in the former series. It is, however, a step further forward in the march of adaptation. The number of digits and the single carpal depart from the normal structure of Reptiles. The digits, without doubt, are altogether of the most decidedly Reptilian conformation; but they are reduced to the normal number possessed by Birds, and the middle digit is the longest of the three. Modification thus begins to be perceptible in the skeleton, and is not confined to the skin only, as in the Flying-squirrels; but this beginning is so weak and so insignificant that one might have doubts about it had the feathers not been preserved. *Archæopteryx*, without doubt, enjoyed the faculty of active flight; but, judging from its weak shoulder-girdle, its reduced sternum, and the slender ridges of its humerus, it must have been but a bad flier. Its tail, so long and so weak, must have been rather a drag than a rudder; and its short rounded wings may perhaps have been sufficient to accomplish short distances, but would not have allowed considerable flights.

The Jurassic *Archæopteryx* doubtless forms a bond of union between Reptiles and the *Odontornithes,* or Birds-with-teeth, of the Cretaceous deposits of America, so admirably described by Prof. Marsh. But we must not forget that a very considerable gap exists between these two types, and that a series of successively modified forms, after *Archæopteryx,* with its dominant Reptilian characters, is needed to reach the *Odontornithes,* among which, except some secondary points in the structure of their vertebræ, the only Reptilian character is the presence of teeth in both their jaws. To sum up, *Archæopteryx* may be regarded as a Reptile flying by means of feathers and perching with the legs of a Bird, while the *Odontornithes* are true Birds, possessing in their skeleton some traces recalling their Reptilian origin. It would doubtless be rash to wish to reconstruct from imagination these intermediate forms—the more rash, seeing that the *Odontornithes* themselves present different forms, showing different stocks, as Prof. Marsh has demonstrated.

We may be yet more embarrassed when we concern ourselves with seeking the direct ancestors of *Archæopteryx.* We wish to see in it an immediate descendant of the *Compsognathus,* found in the same Solenhofen beds; and we forget that ancestor and descendant cannot be contemporaries. Prof. Gegenbaur, in his 'Manual of Comparative Anatomy,' unites *Compsognathus* and *Archæopteryx* in one subclass of Sauropsids, which he calls *Saururi.* It is true that they both have the long Saurian tail; but can one unite a Reptile having no trace of feathers, furnished with very short fore feet, and hind-feet formed like those of Reptiles, except some approximation to those of Birds—in a word, a leaping Reptile having the form of a Kangaroo—and the *Archæopteryx* which we have just been analyzing?

Nor can I familiarize myself more with the view of Prof. Huxley, who sees the ancestors of Birds in the Dinosaurs taken as a whole. I have already remarked that the elongation of the anterior extremities is an indispensable condition of the faculty of flight, and that the Dinosaurs, on the contrary, show the same shortening of these fore-limbs that we observe in animals that leap.

It is true that the Dinosaurs exhibit in the structure of their pelvis, their tarsi, and their digits many approximations to Birds. It is also true that the embryo of Birds shows that the single metatarsal comes from the fusion of the tarsals and metatarsals, which are originally separate, as in Reptiles. We therefore acknowledge here a genetic line, proved by both phylogeny and ontogeny; and we do not hesitate to say that the legs of the Dinosaurs form the bond of union between that of Reptiles, strictly so called, and that of Birds.

But there our genetic line stops, and if we consider the fore-feet we see no approximation. A mere stump renders flight impossible. In my opinion, a genetic line starting from the Dinosaurs could only reach the Ratites. Now we have many indications that this is a very ancient group. A host of points in their anatomy approximates them, more than any other known group of living Birds, to the Reptiles. The *Hesperornis,* of the American Cretaceous deposits, is, according to Prof. Marsh, an aquatic Ostrich, having the keelless sternum and the rudimentary wings of a Ratite. This view, the reasons of which I have just pointed out in a very summary way, without being able to explain them, would compel consequences opposed to the opinions now received. If we adopt it we must see in the wing of the Ratites, not a Bird's wing become rudimentary through disuse, but, on the contrary, an organ which, owing to its origin, has not yet been able to become a perfect wing. We must also see in it the fore foot of a Dinosaur, developed with a view to the organization of a Bird, but tainted with the original fault of being too short and too small, so as to hinder it from becoming an organ of active flight. The Ratites, far from being a degenerate group proceeding from Birds that fly, would be, on the contrary, a primitive group which has not been able to reach active flight.

A second consequence of this view would be the polyphyletic origin of the class of Birds. The Dinosaurs would lead to the Ratites, the *Archæopteryx* to the Birds that fly. Notwithstanding the uniformity in the structure of Birds, broken, it is true, by the Ratites, the class would have at least two stocks in two different groups of ancient Reptiles. At first sight this conclusion appears offensive; but, since many other facts lead us to similar inductions, we cannot repel it *à priori*.

After having refuted the genealogical relations of the Dinosaurs to the *Archæopteryx,* while accepting them as possible with regard to the Ratites, we may ask if we find among the fossil Reptiles anterior to the Upper Jurassic beds, forms which can be allied to the *Archæopteryx,* and through it to the Birds that fly. I must confess that it would be impossible for me to answer this question; I believe even that for a long while we shall not be able to satisfy it. We know only very few complete skeletons of these ancient Reptiles; the limb-bones, and especially those of the digits, are very rare, and nearly always detached. To this difficulty another is added.

As I have already remarked, it would be impossible to suspect, from an examination of the skeleton alone, that the *Archæopteryx* bore feathers. Its adaptations with a view to plumage are so little visible that we could not have taken them for such, had not the calcareous rock of Solenhofen, with its fine grain, preserved the very lightest impressions. Let us suppose for an instant that there had only been found the skeleton of *Archæopteryx,* without any trace of plumage. Would any one have seen in it a flying animal? By no means. One would have seen in it a walking Reptile, high in the legs, like the Chameleons. The anatomist bold enough to assert that this animal had been endowed with the power of flight, and relying for that purpose on the structure of the hind-legs, would have been quickly refuted by considerations drawn from the fore-feet.

But, thanks to the exceptional fineness of the paste of the lithographic stones, the feathers are found, attached to the manus and tail of a Reptile, and to the leg of a Bird. Who, then, could deny the existence of feathers, more or less developed, or more or less rudimentary, in many of the ancient Reptiles, of which we have only found the skeletons or detached bones, embedded in a coarser matrix and one incapable of preserving delicate imprints? I believe I have proved, from what goes before, that the adaptation for flight proceeds from without inwardly, from the skin to the skeleton, and that the latter may be wholly unaffected when the former has already reached the development of feathers. Must we not admit that *Archæopteryx*, whose skeleton has undergone such slight modifications, contrasted with the luxuriant development of feathers, has been preceded by forms of terrestrial Reptiles whose skeleton had undergone no change, among which forms, instead of perfect feathers, there existed only the stumps of rudimentary feathers, such as at present are shown by the embryo of Birds in the egg? The cutaneous structures being destroyed by fossilization in the midst of a coarser matrix, what means would remain for us to recognize in a terrestrial Lizard with a normal skeleton the traces of a rudimentary plumage in the course of development?

To support these considerations I have no need here to recall to mind that the homology between the scales, warts, spines, and other cutaneous structures in Reptiles on the one hand, and the feathers of Birds on the other, has long since been recognized (see Gegenbaur's 'Manual of Comparative Anatomy'), and that all these Reptilian structures differ in nothing from the wart-like stumps which appear in the embryo of Birds as the first traces of plumage—that the Bird's feather is only the Reptile's scale further developed, and that the Reptile's scale is only a feather that has kept the embryonic stage. There can thus be no doubt that the feathers of *Archæopteryx*, so fully developed as they are, must have been preceded, in other, older Reptiles, by cutaneous structures representing the different degrees of embryonic development of the feather. We must therefore picture to ourselves the ancestors of the *Archæopteryx* as terrestrial Reptiles in the form of Lizards, having feet with five hooked and free digits, showing no other modification of the skeleton, but having the skin furnished, in different places, with elongated warts, down, and rudimentary feathers, unfit for flight, but allowing for further development in the course of generations.

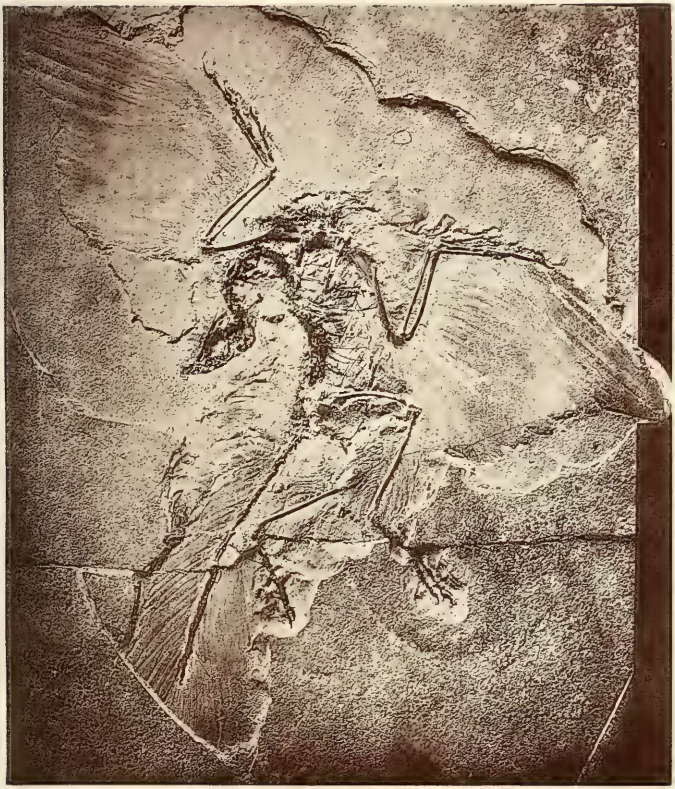
Here I stop. Having made a very imperfect study of the original slab, which requires the most thorough examination, I have only been able to make observations based on inspection of its photograph. But I hope to have shown you that our fossil, unique of its kind, is worthy of the most serious study, by means of which a crowd of questions of the highest scientific interest may be solved. You will, however, find the wish I form very legitimate; it is that this specimen, when it leaves the hands of its present owner, may pass into the possession of an institution or museum where it will be accessible to all who wish to make a thorough study of it.

XLIV.—*Description of a new Genus and Species of Owl from the Seychelles Islands.* By Canon H. B. Tristram, F.R.S.

(Plate XIV.)

It is with somewhat of the feelings of a poacher unprotected by the new Ground-Game Act, that I venture to intrude on a domain so sacred as that of the Mascarene Islands, which Professor Newton and his brother have established as peculiarly their own, and which they seemed to have so thoroughly exhausted. But the temptation is as irresistible as a stray Falcon to a keeper in the close season longing for an excuse to discharge his piece; and I can only, in mitigation of judgment, express my hope that it will not be long before I receive a second specimen of my prize, wherewith to enrich the Professor's unique collection.

I have been lately in correspondence with a gentleman who was making a sojourn in the Seychelles from the



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ARCHÆOPTERYX.